Self Study

Quantitative Ecology and Resource Management
Interdisciplinary Graduate Program
University of Washington Seattle

Degrees offered:
Master of Science
Doctor of Philosophy

Year of last review:
2008

Director:
Timothy Essington

Date submitted:
August 28, 2018

Contents

Required Background Information

1
Overview of the Organization

The Quantitative Ecology and Resource Management (QERM) Interdisciplinary Graduate Program provides a course of study and research opportunities in the application of statistical, mathematical and decision sciences to a broad array of ecological and natural resource management problems.

The QERM program faculty is inherently interdisciplinary, comprising individuals from various departments and Schools (Appendix C). These faculty provide students with opportunities to conduct original research, often in partnership with private and public sector agencies.

QERM offers both the Master of Science and Doctor of Philosophy degrees, producing graduates who develop and apply statistical and mathematical modeling in the academic, agency, or private sector work force.

QERM graduates pursue a variety of careers. While many pursue academic positions and state- and federal agency, many others find employment at consulting agencies and not-for-profit non governmental organizations (Table 1.1).

Table 1.1: Summary of present positions held by QERM graduates between 2008 - 2018

Position Type	Number
Academic	8
Post doc	6
Agency	6
Private consulting	6
Continuing student	5
Non governmental organization	3
Secondary education	2

1.1 Degree Programs

The QERM program offers two graduate degrees: Master of Science and Doctor of Philosophy. Each degree requires the preparation of a either thesis or dissertation, respectively. The completion of a M.S. degree with thesis is normally required

before a student may enter the Ph.D. program. Occasionally, students initially accepted into the master's program will be allowed to proceed directly to the doctoral program as detailed in the Master's Degree By-Pass policy.

The Master of Science (M.S.) degree is an integrated program of coursework and research wherein students master the fundamentals of statistical inference and modeling while also gaining additional expertise in an area of emphasis. The M.S. requires students to complete original research and gain understanding of the biology and ecology of their study system.

The Doctor of Philosophy (Ph.D.) degree is distinguished from the M.S. degree by the greater rigor and depth of research and scholarship. The granting of the degree is based on proficiency in statistical inference, ecological modeling, and resource management and upon a superior ability to carry out important and independent research, as demonstrated by the successful completion of a doctoral dissertation.

1.2 Organization of Unit

Prior to Summer 2017, QERM was housed in the Graduate School, where it had been administered since 1990. Beginning in 2014, the faculty began exploring other options, and the College of the Environment appeared to be a natural choice given that the majority of faculty had appointments in the College. After substantial deliberation, the faculty elected to become part of the College of the Environment and officially transferred in Summer 2017.

QERM has a single administrator (presently, Erica Owens) who is a 50% FTE. The program administrator is supervised by the Director (presently, Tim Essington, previously Loveday Conquest).

1.3 Governance

The Director and the Administrator provide day-to-day oversight of the program. The Director and faculty provide planning and policy for the program.

The Program Director is appointed by the Dean of the College of the Environment, with input from the QERM faculty. Prior to being in the College of the Environment, the Dean of the Graduate School would formally make the appointment, following a vote by the QERM core faculty.

Core faculty members are those that are actively-involved in the program, e.g., serving on graduate committees, assisting with program activities, or serving on any of the committees described below. Faculty members are appointed following self-nomination and a vote by the core faculty. The decision to add faculty is based potential to advise current and /or future QERM students.

Some individuals become less active in the program over time. When this happens, we change the appointment from core QERM faculty to affiliated QERM faculty. This change helps clarify for incoming and first-year students which faculty are actively engaged in the program. This change does not require core faculty vote,

but is instead usually conducted through conversations between the Director and the affected faculty member.

Typically, faculty meetings are held in Autumn. Other faculty meetings are held as needed throughout the year. All QERM faculty members may attend faculty meetings, but only core faculty have voting privileges. Representatives of the graduate students attend the faculty meetings to provide feedback to the faculty and to communicate faculty discussion and decisions to the student body. During the last five years, meetings were held sporadically as was needed to facilitate discussion and planning for the move from the Graduate School to the College of the Environment.

Two faculty committees, each appointed annually, are crucial to the program: the admissions committee and the qualifying exam committee. The admissions committee consists of 3–4 faculty from at least two academic units. They review application files, select individuals for site-interviews, and provide recommendations to the Director. Committee members are appointed by the Director, and the composition changes annually to ensure that many different areas of expertise are represented. The Qualifying Exam committee consists of 4 faculty who each write one portion of the Qualifying Exam (see Appendix F.). The composition of this committee is more stable in recent years, commonly consisting of S. Toth, V. Minin, M. Kot, and either T. Essington or J. Skalski.

1.4 Enrollment and Graduation Trends

Overall enrollment over the last 10 years has fluctuated between 16 and 19 students, without any directional trend (Figure 3.1). This is surprising given the reduction in our base funding - prior to 2013 the Graduate School supported 4 first-year students (3 quarters each), but this was reduced to 3 students beginning in Autumn 2013. We do not expect additional base funding, but encourage QERM faculty to admit students directly into their research programs by offering to match first year funding.

In total, we have admitted 36 students from Autumn 2008 - present. Of those, 17 have completed their terminal degree (one of which completed their MS degree and is now enrolled as a PhD student), 16 are currently enrolled, and 3 are inactive /left the program without a degree.

1.4.1 Enrollment and admissions procedures

All incoming students that do not hold a M.S. degree in a quantitative field must enter QERM through the M.S. degree track. M.S. students can bypass the M.S. degree and enter the Ph.D. track (Appendix F). This policy when enacted for a variety of reasons, but the primary benefit is that it gives students and faculty maximum flexibility.

By requiring all students with similar backgrounds to enter the program in the same way, we avoid having two tiers of students (some who enter into the M.S. track and others who enter in the Ph.D. track). Second, we value the M.S. degree as a significant accomplishment, not a consolation prize for students that are not

successful at obtaining a Ph.D. Thus, our admissions model enhance moral and camaraderie among the students.

Finally, we find that outcomes are improved by requiring students to enter via the M.S. degree track. One reason is that students may enter a research lab without committing to the time and investment that a Ph.D. requires. This is important because the M.S. degree experience is one of rapid professional and academic growth. That growth often leads students to discover new interests and career goals that are quite different from those they had upon admission. Also, this policy benefits faculty members because they do not have to commit to supporting a student for 5 - 8 years upon entry. In other words, both they student and the faculty member benefits from having a trial period. The bypass options means that students that are performing at a high level, who have secured funding, and who wish to continue working with their advisor may do so without the need to formally complete a M.S. thesis.

Students generally favor this arrangement, and students have used all possible degree pathways. In the period since the last 10 year review, two students bypassed the MS degree, seven students obtained their M.S. degree and continued study towards a Ph.D. in QERM, five obtained their M.S. degree and continued study towards a Ph.D. at another institution, and twelve completed their M.S. degree and chose not to continue further study towards a Ph.D.

1.5 Academic Services

The QERM administrator acts at the Graduate Program Advisor (GPA). As GPA, the QERM administrator provides academic service such as: advising students of required milestones, course requirements, and University of Washington (UW) policies; assessing and resolving registration and admissions problems for students; and managing incoming and current student orientation and seminars. The GPA also provides non-academic services, such as budget management, website maintenance, new student recruitment and admissions processes, and coordination of faculty meetings and special events. In addition, students are supported within faculty members' home unit, where administrative staff there oversees payroll and other logistics.

The Director serves as the Graduate Program Coordinator. In this role, the Director meets with each student at least once annually, approves academic committee appointments and thesis /dissertation proposals, and provides career and professional guidance on an ad hoc basis.

2

Student Learning Goals and Effectiveness

QERM's philosophy is to provide students with foundations in statistics, applied mathematics, and optimization during the first year, and then require students to specialize in one or more areas thereafter. Our primary mission is to provide high level quantitative training so that graduates are well positioned for employment opportunities in a wide range of fields. Informal feedback from many of these employers (e.g. federal agencies) confirms that QERM graduates are attractive hires because of their broad and deep knowledge of these fields. This training means that QERM graduates can easily pick up new skills to tackle new problems.

2.1 QERM Curriculum

Since the last 10 year review, the first year coursework has been revised by replacing STAT 512 and STAT 513 (mathematical statistics) with STAT 516 and STAT 517 (stochastic processes). One of the chief reasons is that the latter allows students to learn core statistical concepts in a modeling context. Students also take one course in applied mathematics, two courses in optimization, and one course that covers practical issues of data analysis and statistical inference (with a heavy emphasis on generalized linear models and mixed effects models). Details of course requirements are provided in (section 13.3).

QERM offers its seminar course (QERM 597) twice annually. The Autumn offering (which is required for first year students) gives students an overview of quantitative approaches to ecological and natural resource issues, with a focus on approaches that QERM faculty use. Prior to 2013, this course was taught by rotating faculty on an opportunistic basis. Since then, the course has been taught by the Director and the format has been revised to appeal to a wider audience and to more actively engage students in learning. The course takes a single topic or question e.g., response to climate change, and examines the quantitative approaches used to answer questions related to that topic. Weekly sessions are tied together by student-led discussions on the benefits and limitations of each approach and opportunities to advance the field by combining approaches.

The Winter offering is taken by all QERM students annually. The format and focus changes annually based on student feedback to the Director. Some years students give presentations about their research. Other years the class focusses on particular skills : e.g., how to create an R package; how to use GitHub. Other years the class focusses on the art of giving effective scientific presentations.

2.2 Instructional Effectiveness

As a graduate training program that lacks dedicated faculty lines, our courses are largely offered by other units (statistics, applied mathematics, industrial engineering, fisheries, forestry, biology). Consequently, we have little say in course content, course learning goals, or quality of instruction. This is particularly true for courses taught by faculty who are not part of the QERM program. To maintain up-to-date knowledge of course content and delivery, the Director asks students directly about course effectiveness during annual reviews and during informal conversations at QERM Soup (our weekly informal lunch gathering). When there is a shared view that a course is not delivering the material that we intend, the Director will collect syllabi, hold a meeting with relevant faculty and identify potential alternative courses. The Director also holds exit interviews with all students upon the completion of their degree program. Here the Director asks for feedback on quality of instruction they received and how it can be improved.

We evaluate the overall effectiveness of the graduate training program in a number of ways. One metric is the number of peer-reviewed publications per student for each degree pathway (Figure 2.1). We collated student publications, allowing for a minimum of 1 year lag time between graduation and publication date (e.g. if a M.S. student finished prior to Summer 2017 and had no publications as of Summer 2018, we would omit that individual from calculations). From 2008 - present, all graduates published at least one peer-reviewed paper (the median value for MS students). Students who completed both a MS and Ph.D in QERM published a median of 5 papers, while the 11 students who completed only a Ph.D. published a median of 2 papers from their graduate work (but the mean is greater than 3). Two students choose the Ph.D. bypass option (section 13.1), and both were highly productive, producing 6 and 7 publications each.

A second metric of effectiveness is time to reach degree. The modal time-to-degree for MS students is 10 quarters (2.5 years), though there is a long tail (maximum 24 quarters) (Figure 2.2). A sizable number of M.S. students (n = 7) took longer than 12 quarters to complete their degrees. In general, the time-to-degree for QERM M.S. students reflects the fact that many incoming students lack formal training in environmental sciences. Additionally, the rigorous and interdisciplinary first year coursework prevents students from beginning thesis work until their 4^{th} quarter. Also, in some cases longer graduate times might be typical for students' chosen discipline. In other cases, there may be additional factors at work. We can improve student outcomes by identifying causes for longer (>12 quarter) graduate times and implementing strategies to minimize their occurrence and consequences.

Time-to-degree is highly variable for Ph.D. students (Figure 2.2). Students who received their M.S. from QERM and then enrolled in the Ph.D. program had by far the fewest quarters to degree (ranging from 10 to 14 quarters). Ph.D. bypass students (n = 2) took 21 and 24 quarters to complete entire degree program. The median time to degree for remaining students is 25 quarters (6.25 years). Many of the students who took substantially more than this held full time jobs at federal agencies. Two students who took leave to pursue employment or other opportunities took more

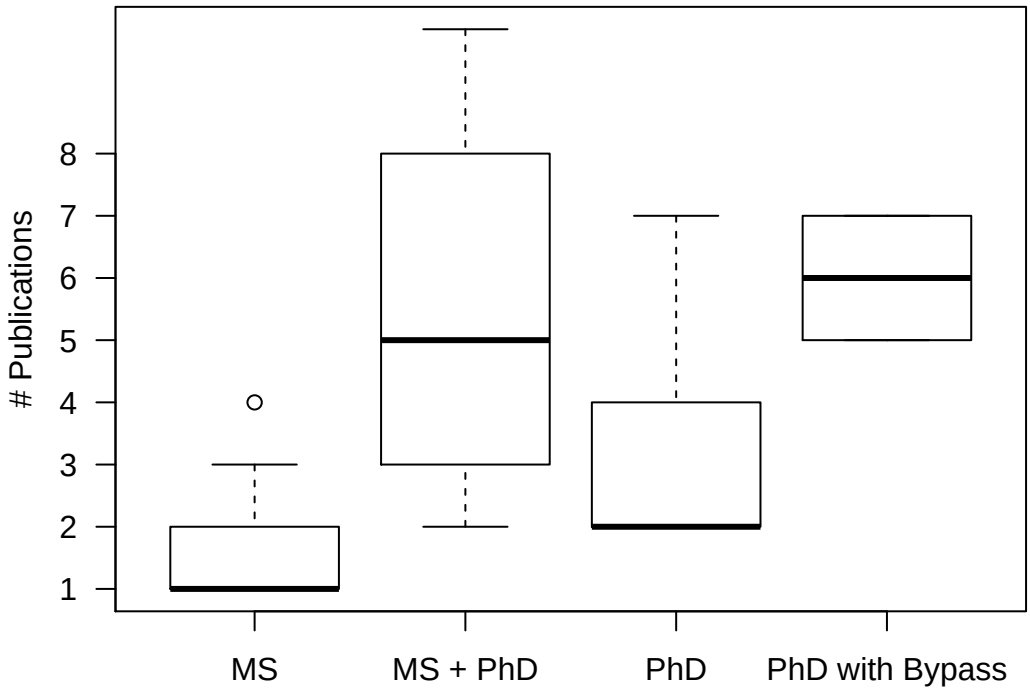

Figure 2.1: Box and whisker plot of peer-reviewed publications by student degree type

than 50 quarters to complete degree (these and are not included in the chart).

2.3 Evaulation Methods and Responses

For QERM-based courses, we use Office of Educational Assessment together with direct conversations with students to gain feedback on instructional quality. Since the Director began teaching QERM 597 in winter 2015, course evaluations have been positive (**??**).

The remaining QERM course, QERM 514 "Analysis of Ecological and Environmental Data," has had more variable course evaluations (**??**), reflecting the uncharacteristic frequent change in instructor. From 2013 - present, overall course evaluations have varied from 3.2 to 4.9. Prof. Sarah Converse taught the course in 2018 and will likely be teaching this course annually for the foreseeable future, providing some much needed stability to this course offering.

The Ph.D. qualifying exam provides another way to evaluate how well the courses meet program learning goals. This exam is offered once a year, after Spring quar-

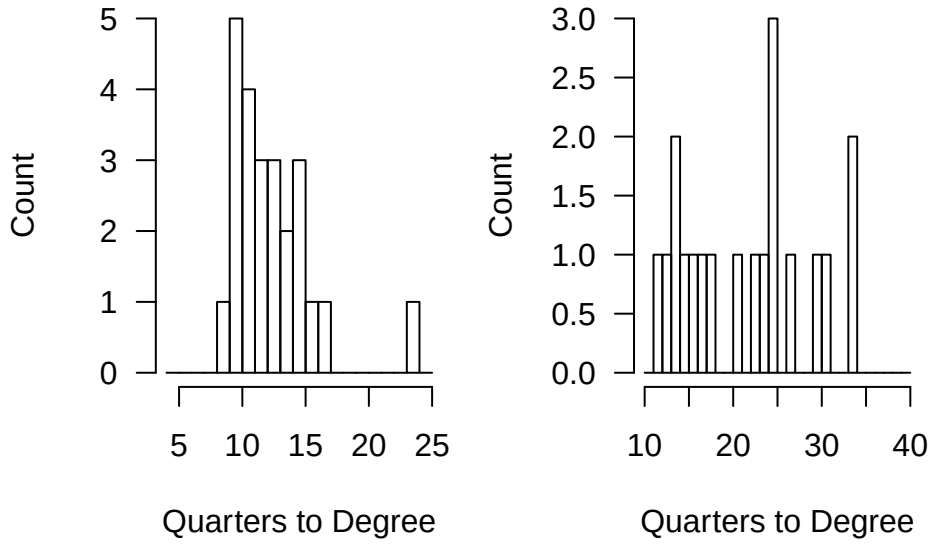

Figure 2.2: Number of quarters from enrollment to degree completion for M.S. (left) and Ph.D (right). The figures on the right include students who completed their MS in QERM and then began a Ph.D. program. The shorter time-to-degree counts are generally those who began the QERM Ph.D. Program after finishing a QERM M.S.

Table 2.1: Adjusted overall median OAE evaluations for QERM courses. 3= Good, 4 = Very Good, 5 = Excellent. Adjustments sometimes lead to median scores that exceed 5

Academic year	Autumn QERM 597	Winter QERM 597	QERM 514
2013 - 2014	NA	4.6	4.5
2014 - 2015	4.7	4.9	3.2
2015 - 2016	not available	not available	Not available
2016 - 2017	4.6	4.7	3.3
2017 - 2018	4.5	5.1	4.9

ter finals week (section 13.2). Although it is a Ph.D. qualifying exam, most M.S. students also take the exam because they prefer to take it immediately after the first year coursework rather than waiting until they decide whether to enter the Ph.D. program. In at least one case we found consistent deficiencies across student exam responses that suggested that a course was not meeting programmatic learning goals. The Director also gives feedback to the QERM 514 instructor on overall student performance on the applied statistics section so that the course can be modified.

2.4 Teaching and Mentoring outside of the classroom

Graduate student mentoring is at the forefront of QERM's mission. Like faculty in any program, QERM faculty mentor students on their research and give guidance on courses and other learning opportunities. QERM faculty also give guidance on professional and career development. QERM students often benefit from having federal agency scientists on their committees. The Director acts as the Graduate Program Coordinator, who is widely available for guidance. The Director meets with each student annually to discuss progress towards degree. QERM has recently changed the format of this annual meeting to allow the students to pose wide-ranging questions about career advancement, successes and barriers to achievements in their own work, and how to overcome problems.

3
Academic Unit Diversity

3.1 Diversity Plan and Committee

As a small unit with only a single (50% FTE) staff member, we rely on our parent unit (first the Graduate School, now the College of the Environment) to oversee diversity efforts. The College of the Environment is deeply committed to diversity equity and inclusion. In Autumn 2017, the College hired its first assistant Dean for diversity. He and college leadership have mapped out plans to enhance recruitment of underrepresented groups and improve the experience of those individuals when they arrive.

By happy accident, QERM is housed in the same building and floor as UW's MESA program (Mathematics, Engineering, Science Achievement). We are in the early phases of developing a relationship with MESA and will encourage our students to serve as tutors as part of their volunteer program. We are excited about fostering further collaboration with this program.

3.2 Diversity of Unit Faculty and Staff

QERM has improved gender diversity over the past few years. After the retirement of Loveday Conquest in 2013, QERM faculty included only two women. Since that time, we have added three women faculty, and we are presently engaged in conversations to recruit three others (wildlife ecology, biostatistics, and economics). The composition of the QERM faculty is not ethnically diverse, reflecting the overall ethnic composition of environmental faculty at UW. 26 of the 28 faculty are caucasian. As QERM does not have any faculty lines, we have limited ability to improve the pool of available and interested faculty.

Among the students, gender diversity has shifted over the past 10 years (Figure 3.1). From early 2008 to 2014 there was a decline in female students and a slight increase in the number of male students. We have gender-specific statistics on graduate offers and acceptances from 2014 onwards that sheds light on the gender imbalance. Annually, between 55% and 66% of total applicants were female between 2014 and 2018. Offers were generally balanced between genders, with a slight tendency towards more offers to female applicants (Figure 3.2). However, the acceptance rate was low in 2014 and 2015. The low acceptance rate was likely due, in part, to the limited number of women faculty during that time. Since we have added additional faculty, a larger number of female applicants have accepted

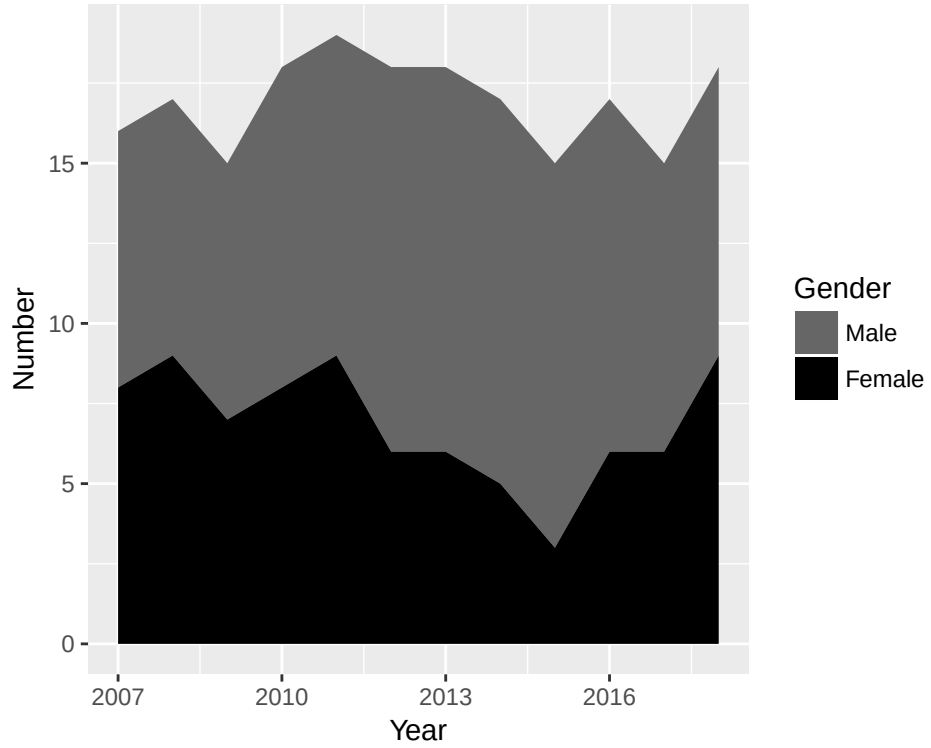

Figure 3.1: Breakdown of students by gender, 2007 - 2018

offers. By Autumn 2018, the program will have equal numbers of male and female students.

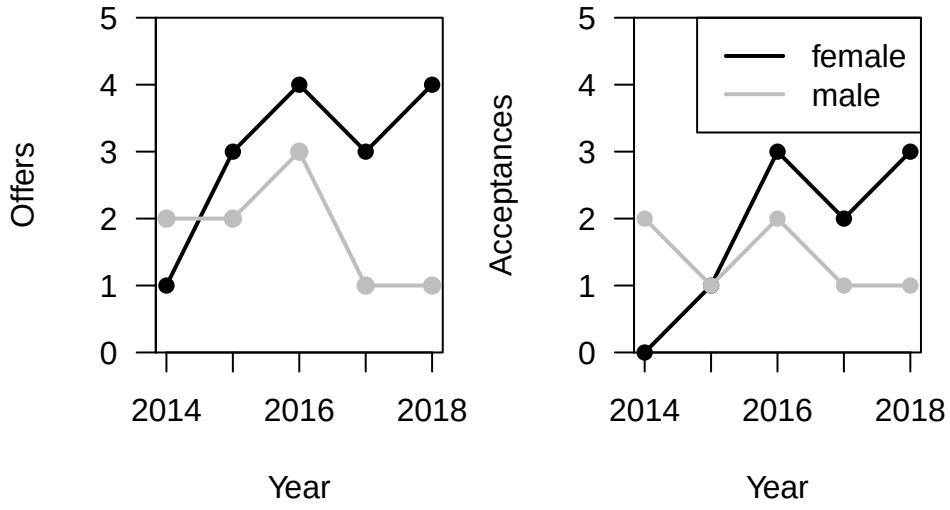

Figure 3.2: Trends in admission offers (left) and acceptance (right) for males and females

Ethnic composition of the program is overwhelmingly caucasian and domestic. From 2008 to present, there have been between 1- 2 ethnic minorities and 1 - 3

international students enrolled in the program, compared to 11 - 15 caucasian U.S citizens enrolled. This imbalance reflects two things. Between 2009 to 2018, our applicant pool contained only 36 individuals from underrepresented groups, and 40 international applicants (though nearly 1/3 of the international applicants were from a single year, 2018). This is out of a total of 264 applicants over this time period. We therefore have a recruitment and pipeline issue. Second, our offer rate of underrepresented ethnic groups is lower (14%) compared to caucasian and international applicants (26%). While the acceptance rate is not significantly different between caucasians and ethnic minorities (p value = 0.21), we recognize that we receive very few applicants from African American, Hispanic American, and American Indian students, and we have offered none over the review period. We clearly need to improve our ability to recruit applicants from these underrepresented groups.

3.3 Environment

QERM strives to provide an environment of tolerance and inclusion. As a small, socially cohesive program, our students support and advocate for one another. Weekly "soup" brings together students, faculty and staff for informal conversation over lunch. The Administrator and Director, in their roles as Graduate Program Advisor and Graduate Program Coordinator, keep tabs on the culture of the program through structured and unstructured conversation.

4

Scholarly Impact

As a graduate training program, we focus here on the impact of students, rather than faculty, while providing overviews of faculty research areas.

4.1 Impacts of program graduates

We identified peer-reviewed publications written by all students who graduated between 2008 and 2018. For each publication, we noted whether the work was conducted during their graduate degree period, or whether the work was based on post-graduate work. We also separately identified first authored from non-first authored publications.

By all measures, QERM graduate students are a productive group and their productivity continues well after their degree program is completed (Figure 4.1). The students enrolled between 2008 – 2018 published a total of 85 peer reviewed publications from work that was conducted as a graduate student. Of those publications,

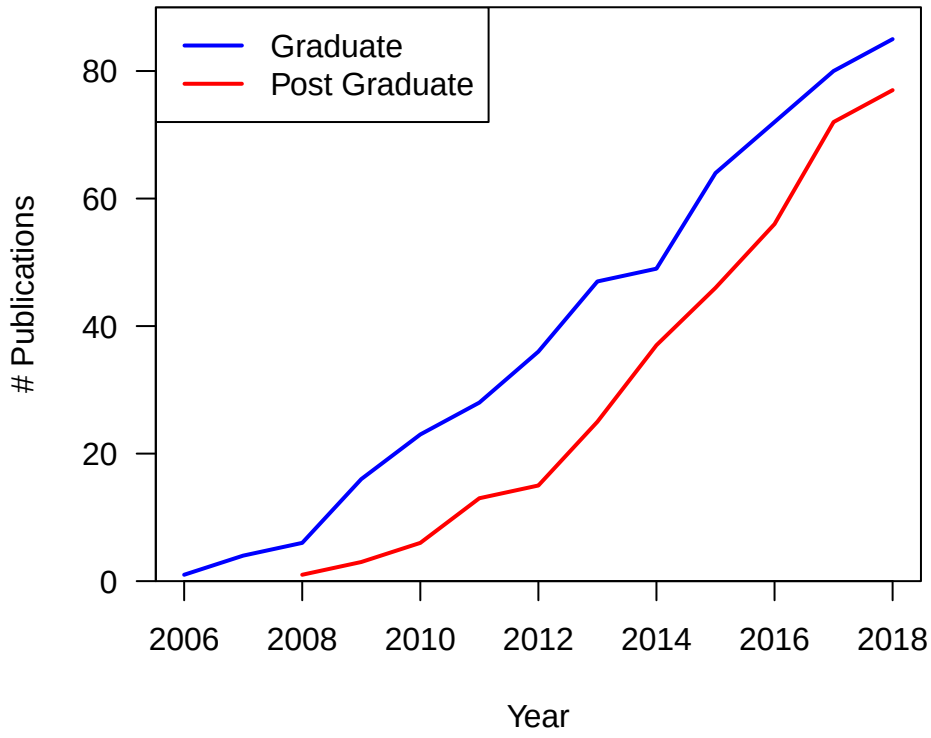

Figure 4.1: Cumulative rate of publication of student publications of work that was part of QERM degree (blue) and work that was produced from research commencing after graduation (red)

the vast majority (52) were first authored, indicating that students were leading these research efforts. A list of publications appears in Appendix D. The main journals are: Proceedings of the National Academy of Sciences; Nature communications; Methods in Ecology and Evolution; Ecology; Ecological Applications; Biological Conservations; Journal of Applied Ecology; Journal of Animal Ecology; Fish and Fisheries; Canadian Journal of Aquatic and Fisheries Sciences, ICES Journal of Marine Science, Fisheries Research; Ecological Modelling; Freshwater Biology; Stastica Sinica;PLoS One; Canadiaon Journal of Zoology.

Our graduates continue to make contributions after graduation (Figure 4.1). Of the students enrolled in 2008 – 2018, 39 have graduated (terminal degree) as of Spring 2018. These students show a high level of scholarly productivity, producing 78 additional publications.

4.1.1 Student Fellowships

National Science Foundation Graduate Research Fellowship: Kiva Oken, Colin Okasaki, Lillian McGill

NOAA Population Dynamics Fellowship: Elizabeth Ng, Christine Stawitz, Ian Tay-

lor, Cole Monahan, Jeff Rutter, Kevin See

NSF IGRT Program on Ocean Change Fellowship: Christine Stawitz

North Pacific Research Board Fellowship: Elizabeth Atwood

4.1.2 Awards and other Notable Achievements

— Maureen Kennedy: 2014 Outstanding Paper in Landscape Ecology. US Regional Association of the International Association for Landscape Ecology.

— Aditya Khanna: 2013 Best Student Paper (Honorable Mention), Sunbelt: International Network for Social Network Analysis. 2013 Appointed as a gonfalonier at UW Commencement 2013, as one of two graduating doctoral students who exemplify "the ideals of graduate education at UW: excellence in learning, teaching, mentoring and/or research." 2009 Best Poster Prize (Co-winner), UW Center for Statistics and Social Sciences, 10th Anniversary Conference.

— Cole Monnahan appeared on BBC and several other news outlets to describe his work "Do ship strikes threaten the recovery of endangered eastern North Pacific blue whales?"

— Kiva Oken UW College of the Environment Dean's Visualization Prize (2012).

4.2 Broad impact and Research Themes

QERM faculty and students contribute to environmental science and decisions sciences in several ways. In addition to peer reviewed publication, faculty and students are often engaged directly in decision making processes. For instance, several members of our aquatic faculty serve on regional fishery management council science and statistical committees (C. Anderson, Punt, Hilborn), or work with the International Whaling Commission (Branch, Punt). Students and faculty also contribute by creating and publishing R packages (e.g. ss3sim, r4ss)

The QERM faculty members are highly productive. Though publication metrics can never fully describe the contribution of an individual to a field and are highly variable across disciplines and have gender biases, we nonetheless note that we have several (n = 4) faculty members with H indices that exceed 60, and roughy one-third of the faculty's H - indices exceed 30. Please see Appendix C for more detailed information on individual faculty contributions and achievements.

The main areas of student and faculty research are described below. We note that global change is a main theme that runs through all of these areas, mirroring trends in the broader research community. We also note that only this list only emphasizes main themes of research, and that some areas of research in QERM are growing (e.g. ecological economics) but are not yet main themes of QERM student work. In addition, Appendix C lists the primary appointing unit for each faculty: current

core faculty come from Applied Mathematics, Biology, School of Environmental and Forest Sciences, School of Aquatic and Fishery Sciences, and Global Health.

Mathematical ecology. Primary Faculty: Mark Kot, Jim Anderson, Lauren Buckley, Andrew Berdahl (new faculty joining Autumn 2018)

QERM students and faculty apply mathematical models to reveal general phenomenon and advance, generate, and test hypotheses. The types of questions that are posed are varied, and have included: How can species persist in an environment when habitat is moving (Phillips and Kot 2015)?; How does asymmetric dispersal pattern affect model predictions, and how can models account for them (Rinnan 2018)?; What rules govern animal movements (Bracis et al; 2015; Gaurie et al. 2016)?; How can models account for individual heterogeneity in dispersal (Gaurie et al. 2009)?; How can the vitality concept be used to understand population survival and demographic heterogeneity (Li and Anderson 2009)?; How detectable is predation in stage-structured populations (Oken and Essington)?; How do tradeoffs among multiple objective give rise to diversity of foliage morphology (Kennedy 2010)?

Optimization for decision making. Primary Faculty: Sandor Toth, Sarah Converse

The addition of Sandor Tóth to the UW and QERM provided more opportunities for students to specialize in optimization methods for decision making. Since joining QERM, his lab has been highly active in both method development and applications to real world problems. Applications include rotational harvesting to reduce edge effects (Ross and Toth 2016) and to minimize financial and ecological costs of forest roads, as well as optimal survey design for aerial surveys. Methods include: quantifying trade-offs in multi-objective optimization (Kullman 2016 MS thesis); developing models to account for stage-specific habitat requirements in conservation planning (Burns et al. 2013); incorporating population dynamics via difference equations in optimal harvest scheduling (St John and Toth 2015).

Sarah Converse joined UW and QERM more recently (Winter 2017). Her research program focuses on decision science regarding population conservation. She is advising two QERM students presently.

Statistical Ecology. Primary Faculty: Peter Guttorp (retired), Vladimir Minin (departed UW), John Skalski, Beth Gardner

While statistics is pervasive throughout QERM, here we refer to the specific development of statistical tools to answer ecological questions. The addition of Beth Gardner (’17) brought new strength in spatial mark-recapture methods specifically, and Bayesian methods in general. This work complements the strong program of John Skalski who applies mark - recapture methods for fish and wildlife population assessment. QERM faculty and staff also improve methods for using random effects models for population reconstruction (Gast et al. 2013), developing state-space models to assess variation in somatic growth rates (Stawitz et al. 2015) , illustrating the implications of no-U-turn hamiltonian sampler for Bayesian poste-

rior simulation (Monnahan et al. 2016); and improving estimates of extinction risk by adjusting sampling methodology (See and Holmes 2015)

Aquatic Ecology, Conservation, and Fisheries. Primary Faculty: Chris Anderson, James Anderson, Trevor Branch, Tim Essington, Vince Gallucci (retired), Ray Hilborn, Gordon Holtgrieve, John Horne, Julian Olden, André Punt, Jennifer Ruesink, Daniel Schindler, John Skalski.

This is a major area of focus of QERM students and faculty. In fact, more than two-thirds of QERM students from 2008 - present have worked in this thematic area. Because of the large number of students and contributions, we do not identify all of them but instead list research themes of QERM faculty. Holtgrieve, Olden and Schindler bring expertise to freshwater ecosystems, and their labs and QERM students evaluate portfolio effects in structured populations, application of stable isotopes to understand biogeochemistry and food web structure, invasive species dynamics, and landscape conservation and hydropower consequences. Essington, Gallucci, Ruesink, Horne, Punt, and Branch work primarily in the marine and estuarine realm, tackling issues related to impacts of environmental heterogeneity, effects of fisheries and other anthropogenic effects on populations and food webs, and methods to evaluate environmental impact through acoustic monitoring. Students work on a wide range of topics from genetic differentiation and implications for fisheries management (Spies '14), designing and managing freshwater flows (Chen '17), management strategy evaluation for marine fisheries subject to environmental change (AMar '09), and population dynamics of protected species (Nesse '09). QERM greatly benefits from the strength of the UW- School of Aquatic and Fishery Sciences in fisheries stock assessment. QERM students conduct research to improve stock assessment methods, while also conducting assessments for the North Pacific and Pacific Fishery Management Councils.

Forest Ecology and Management. Primary Faculty: Ernesto Alvarado; E. Ashley Steele, Patrick Tobin, Brian Harvey (pending faculty vote), David Ford (retired)

QERM's connection to the School of Environment and Forest Sciences remains strong and provides opportunities for students to pursue research in forest ecology and management. Ashley Steele has been especially effective at bridging connections between QERM, Department of Statistics, and the U.S. Forest Service. Students are engaged in issues related to forest fires (their impact and prediction; Barbero et al. 2014) and tree physiology and life history (Kennedy 2010).

Wildlife Ecology and Conservation. Primary Faculty: Sarah Converse, Beth Gardner, Josh Lawler, John Skalski, Patrick Tobin, Aaron Wirsing.

QERM students work on population estimation (Broms et al. 2010), impacts of habitat loss on wildlife predator prey relationships (Vitense et al. 2016) , and assessing population vulnerability to climate change (Rinnan 2017). Currently-enrolled students are evaluating habitat needs, distribution, and population estimation of wildlife.

4.3 Interdisciplinary Research

Naturally, as an interdisciplinary training program, QERM encourages and fosters collaborations among University of Washington Faculty. Here, we define interdisciplinary research as activities that combine distinct quantitative approaches or fields of study. For instance, Austin Phillips (Ph.D 2016) applied his theoretical ecological approaches of species persistence in moving habitats to optimization problems regarding protected areas. This work combined the expertise from Mark Kot and Sandor Tóth, applying mathematical ecology with sophisticated optimization methods. Scott Rinnan (Ph.D. 2018) combined theoretical models to landscape scale questions of population viability and climate change. Aditya Khanna's (Ph.D. 2012) dissertation brought together faculty from Anthropology, School of Medicine, and Statistics to develop mathematical models of HIV infections, While Ting Li's (Ph.D. 2011) brought together mathematical biologists, anthropologists, and statisticians to human mortality. Many, if not most, QERM graduate committees include faculty from multiple units. Participation in QERM permits faculty in different units to know each other better, and to engage in scientific discussion around student thesis or dissertation work. Additionally because QERM students are imbedded within other units, they gain the opportunity to learn more broadly from faculty and students in those units.

4.4 Promotion and Tenure

As an interdisciplinary graduate training program, QERM does not make decisions on promotion and tenure. Rather, we make decisions on which faculty join the program, and when to remove individuals.

5

Future Directions

This section focuses on current opportunities for QERM, and use the Part B questions to think more deeply about QERMs future. The program is benefiting from a number of new opportunities stemming from our move to the College of the Environment. We have much improved facilities in the Ocean Teaching Building, with usable shared office spaces for graduate students, communal kitchen space for weekly lunch gatherings, and a large conference room /collaborative work room. We recently were able to use the College's Graduate Research Opportunities Enhancement funding to recruit a top graduate applicant into the program in 2018. The college marketing and communications team is helping us update our web site, and the advancement office has been active reaching out to alumni and other po-

tential donors. We are now taking steps to more formally connect QERM and the Center for Quantitative Sciences program.

QERM is also benefiting from the wave of outstanding assistant professor hires in the College. We have added Beth Gardner, Sarah Converse, Andrew Berdahl, Brian Harvey, and Patrick Tobin to the QERM program. Gardner, Converse, and Berdahl have already been particularly engaged in the program.

5.1 Opportunities and How to Seize Them

QERM and the College of the environment are working towards merging the Center for Quantitative Sciences and QERM. The Center for Quantitative Sciences has a long history at the UW. Formed in the late 1960's, the mission of the Center was to establish an interdisciplinary undergraduate teaching program in mathematics and statistics for natural resources students. Center for Quantitative Sciences faculty played a key role in the formation of the Graduate Biomathematics Program, which eventually led to the formation of the Quantitative Ecology degree track. Prior to 1990, the Center and Quantitative Ecology shared facilities and were often viewed as being a single entity. Many QERM alumni refer to themselves as "CQS" graduates. After the remodeling of the Center building in 1990, the Quantitative Ecology degree became the Quantitative Ecology and Resource Management degree, and was transferred administratively to the UW Graduate School. The Center's undergraduate courses have been part of the College of the Environment since the College's inception and are managed jointly by the College and School of Aquatic and Fishery Sciences and the School of Environmental and Forest Sciences. QERM became part of the College of the Environment in Autumn 2017.

We are presently taking action to reconnect these to programs. This will streamline administration (budgeting, etc.) by having a single individual overseeing both program's budgets and budget planning. It will also help us align the undergraduate coursework and quantitative sciences minor with the QERM graduate requirements. Finally, it will allow us to better map the quantitative course work available to the College graduate students and suggest course pathways for students looking for advanced quantitative training.

— Improved efficiency in administration via a single Director, single location (Ocean Teaching Building), and single annual budgetary review as part of the College budgeting process

— Improved efficiency in advising

— Improved coordination of non-core 400 level undergraduate courses that largely target graduate students

— Improved web presence for both undergraduate quantitative science (QSCI) and graduate quantitative science (QERM) via a single Center for Quantitative Sciences webpage.

In addition, we are also reviewing our graduate application review process to determine whether our criteria reflect the traits that make students successful in our program. We will review how academic achievements (grade point average, GRE scores) are predictive of student achievement in both first year coursework and other metrics of performance.

5.2 Where is the Unit Headed?

Our Part B "Unit Questions" are essentially formulated around this question. There we ask a series of strategic and tactical questions regarding QERM's future. Rather than repeat those here, we refer to Part II.

6

Strategic

We pose three broad questions related to the long term vision for QERM:

1. How does QERM maintain it's unique niche given the increasing bar for quantitative competency in ecology and natural resource management programs in general? How does QERM stay ahead of the bar in a rapidly changing field?
2. Are the core curriculum requirements adequately preparing students to be at the cutting edge in quantitative science?
3. As an interdisciplinary training program, are we effectively leveraging the graduate training program to enhance interdisciplinary quantitative research?

6.1 How does QERM maintain its unique niche?

Ecology and resource management is increasingly become a heavily quantitative field. Most research requires application of statistics and modeling that would be considered "advanced" 20 years ago. Generalized linear models, hierarchical models, and Bayesian methods are now *de rigeur*. Mathematical modeling has been a part of natural resource management for decades, but access to relatively fast personal computers means that more people can use statistical and mathematical models to generate and evaluate hypotheses. And the field generally expects training in these tools. This expectationimplies that the training QERM provides is uniquely suited to prepare students for careers in ecology and resource management. But it also implies that many graduate programs have evolved to provide advanced quantitative training as well. How can QERM stand out by offering something unique?

We view interdisciplinarity as our primary strength and distinguishing feature. Our students gain broad training in statistics, applied mathematics (modeling) and optimization. They then gain specialized training in subdisciplines. The University of Washington is an ideal environment for this training, with many quantitative faculty available to mentor and to provide advanced coursework. The University and QERM also provides tremendous breadth of research areas: aquatic to terrestrial, ecology to decision science and economics, modeling to statistics, basic to applied ecology.

QERM is also distinguished from other programs by the background of our incoming students. Many QERM students arrive with modest backgrounds in ecology or natural resource management, but have strong quantitative training via undergraduate degrees in mathematics or statistics. QERM therefore is a place where students can discover applications of their quantitive skills to environmental problems.

Finally, QERM is not just a training program for graduate students; it is a community. QERM prides itself on the strong social connections among students. This strong social fabric provides a support system, fosters collaboration, and encourages even greater interdisciplinary work.

6.2 Preparing students to be at the cutting edge

Our current curriculum consists of training in statistics (stochastic processes), applied statistics, applied mathematics and optimization. We do not cover topics such as computer science, machine learning, data management, and no longer require the mathematical statistics course series. What principles should be used to guide expansion into new disciplinary areas?

While practical considerations will always loom large over these types of decisions (e.g. course access, student preparation, faculty availability), here we focus on the strategic consideration. Our basic approach is to be opportunistic based on the faculty that comprise UW departments and Schools. That is, individual units at the UW are good at finding individuals working on the cutting edge and tackling important problems. When these faculty searches are successful, QERM benefits from the influx of faculty working on new topics. We also expand disciplinary area via student interests: one of our primary ways of recruiting faculty is when a first year student wishes to work with a faculty member. Thus, as the interests of incoming students evolves, QERM has the capacity to evolve faculty ranks accordingly.

What is less clear is the extent to which QERM should be more strategic in approaching faculty members and evaluating course requirements. Moving forward, we suggest appointing an executive body consisting of the Director, 2–3 core faculty, current students, and alumni. The charge of this body would be to bi-annually review current developments in course offerings, faculty searches occurring in other units, and make recommendations regarding future directions of the program. In this way, a broader group of individuals can be involved in ensuring that QERM evolves and adapts.

6.3 Enhancing interdisciplinary quantitative research

While we pride ourselves on being an interdisciplinary program, individual research projects are, for the most part, focused on applications of quantitative methods within disciplines (for exceptions, see section 4.3). This means that while students obtain broad training in multiple quantitative methods, they typically apply a smaller number of methods in their research. In many ways this reflects a natural progres-

sion of learning – it is unreasonable to expect a M.S. student who is learning about ecology and natural resource management AND learning about quantitative tools to also integrate tools and approaches across multiple fields. However, we might expect a Ph.D. student to have a broader focus than say, a Fisheries, Forestry, Statistics or Applied Mathematics student, particularly if we conclude that doing so better prepares them for their careers.

We see two possible approaches to foster more interdisciplinary research. The first is to require some interdisciplinary research in Ph.D. dissertations. The second is to encourage and support students pursuing interdisciplinary research efforts. For several reasons, the second of these is most appropriate. We detail reasons below.

While interdisciplinary research will certainly benefit many students, it may hinder to others. For instance, some students are pursuing a very clear career pathway that requires specialization, so interdisciplinary requirements might disadvantage them.

In addition, there are practical barriers to imposing an interdisciplinary research requirement. Most students are supported on grants and contracts that have specific deliverables. The program cannot require these students to do work above that required by the terms of their academic student employment. Thus an interdisciplinary research requirement would require additional student funding, which is not likely to be granted.

We see greater potential by strengthening the culture that encourages interdisciplinary research. Interdisciplinary training programs have been trialed and even established for long enough for the challenges and opportunities to be understood (e.g. Graybill et al. 2006 Bioscience 56: 757 - 763; Campbell 2005 Cons. Biol 19: 574 - 577). Key lessons include the need for careful planning for student progress towards their own research and educational milestones, the need for flexibility in the plans to account for unpredictable challenges that arise, and the importance of rewarded outcomes from interdisciplinary work.

The foundations for stronger interdisciplinary science within QERM already exists. The shared focus on quantitative sciences provides a common language (and a common approach). Our academic milestones already reflect the unique backgrounds of incoming students and broad training that the program requires. QERM could enhance interdisciplinary research by making a more concerted effort to encourage, and even celebrate interdisciplinary work, such as that described earlier (section 4.3). QERM could also further enhance the culture of interdisciplinary research by providing support for side-projects (outside of student's main work that is largely funded from grants with specific deliverables). Support could be in the form of guidance from the Directory or faculty in writing grant /fellowship proposals, or mentorship on the projects themselves. Finally, the Director could work more closely with faculty in preparation of interdisciplinary grant proposals by emphasizing the availability of broadly trained quantitative students that the QERM program can provide. QERM can also place limits on the number of QERM faculty members whose primary appointment is shared with that of their major professor. That would provide a broader breadth of expertise on committees, while also creating more opportunities for faculty to exchange ideas.

7
Tactical

We pose two questions related to our year-to-year operations and challenges that we currently face:

1. How can QERM best address challenges of being a small program
2. Does the current first year funding and course work model still provide the best ways of attracting and preparing students?

7.1 Confronting “small program” challenges

As a small program, QERM regularly faces multiple challenges. They include gaining access to heavily subscribed courses (and lack of leverage or resources to facilitate access), limited ability to craft curriculum or guide course content, and risk of losing critical mass of first year cohorts. We discuss each of these in turn below.

7.1.1 Course Access and Content

Access to some courses, especially optimization, has been challenging over the past few years. We require that students take introductory level optimization coursework, and find that IND E 512 or IND E 513 provide an ideal blend of theory and application. Yet access to these courses is limited because many other degree programs require them. For instance, optimization courses satisfy elective requirements for the Computer Engineering undergraduate degree and the Industrial and Systems Engineering graduate and undergraduate degrees. Additionally, QERM has no say over the scheduling of courses, so each year we must adapt our curriculum in response to constantly shifting course offerings.

Also, course learning goals and content can change quickly when new instructors take over courses. For instance, STAT 517 in Autumn 2017 course content was radically different from previous years. Consequently, we must explore other courses that might better provide the high-level training in statistics that we need.

When aforementioned issues become persistent, QERM can alter course requirements, find alternative courses (e.g. require the more theoretical optimization courses offered through MATH /AMATH), or develop our own course. The latter is only feasible if we can find suitable instructors and make the course of broad interest to quantitative students throughout the College. The Dean of the College of the Environment has expressed her willingness to assist wherever possible, and it may prove to be necessary to solve the optimization course challenge.

Additionally, having a more formalized executive body as described in section 6.2 to continually review course materials and course offerings will allow us to adapt more quickly to the ever-changing curricular landscape.

7.1.2 Cohort Size

We presently have funding to support three students annually during the first three quarters of their degree program. This funding allows students to focus on their coursework and on selecting an advisor, without the additional demands that accompany funding on grants and contracts. Many QERM faculty feel that annual incoming student cohort size of 3 is the bare minimum needed to obtain critical mass, and that larger cohort size is beneficial. The students generally work closely together throughout the academic year as they are taking the same courses e.g. work together on homework, exam preparation.

Our admissions process resulted in small incoming cohorts (n = 2) in several years. A chief reason was that we initially only gave three admission offers, and would only gave additional offers when offers were declined. This was ineffective when students waited until mid April to decide, because by then the other highly qualified candidates had already accepted other offers. Beginning spring 2016, we began offering more positions than we could fund, with the expectation that a certain number would decline. The Graduate School, and now the College of the Environment, have offered to cover unexpected additional costs should more than three students accept (with the understanding that our funding would be diminished in future years). This has proven to be very effective, as we reached our target incoming cohort size in every year for the past 3 years.

We still seek ways to grow the cohort size so that we admit between 3–5 students annually. See section 7.2 for additional conversation.

7.2 First Year funding

QERM admissions are unique compared to other ecology and natural resource programs, as students are admitted without having selected a committee chair or a research project. This allows students who enter the program with degrees in statistics or mathematics to use the first year to learn more about ecology and resource management, the types of research that is being done, and develop a rapport with their committee chair before joining their research program. Yet this model has disadvantages as well. Some prospective students have expressed unease with the prospect of accepting an offer without knowing what research topic they will work on or with whom they will work.

Because the benefits of our current model are important for many of our incoming students, we do not wish to abandon it entirely. For that reason, we implemented a hybrid admissions process beginning in Autumn 2016. Here, we allow faculty to select among the top - ranked applicants and offer a 1:2 quarter match in funding if they wish to admit them into their lab. We also allow faculty to admit any student

deemed “admissible” with a funding commitment (much as other natural resource and ecology programs do).

The hybrid model has only been used once since implementation. One obvious barrier to wider use is that faculty are clever and have therefore calculated that it is in their best interest (from a funding perspective, that is) to work with students who receive a full 3 quarters of QERM support. A second has been communication: admissions take place at the same time as most of the faculty’s appointing units’ admission. As a result, we have not effectively communicated the pool of potential applicants and the process for admitting them in the hybrid model during this busy time of the year. The admissions committee could do a better job of reaching out to specific faculty regarding applicants that would be a good match to their research program.

Appendices

8

Appendix A. Organization Chart

Because QERM is a small unit with only two individuals in administrative roles, we refer the review committee instead to section 1.2.

9

Appendix B. Budget Summary

The QERM budget consists of two main components (section 9.1): (a) the State budget, which provides funding for graduate research assistantships (12 quarters of funding per biennium), supports an 0.5 FTE administrative position (Graduate Program Advisor), and benefits associated with these positions, and (b) the Indirect Costs Supported budget, which covers basic operating expenses ($12,000/biennium) and the Director's administrative stipend and associated benefits.

Over the last three biennia, the largest allocation of the QERM budget has been to first-year student salaries and benefits (typically between two thirds and one half the budget). The amount spent on student salaries and benefits fluctuates annually depending on the number of students accepted into the program each year (Figure 9.1). QERM's base funding supports a maximum of 6 quarters of funding per year, which supports two students for the first three quarters annually. Note that an additional 3 quarters of graduate student support derives from the Graduate School Hall-Ammerer fellowship but is not included in our budget. With the recent move to the College of the Environment, the College has guaranteed a comparable amount of support for student funding. If more or fewer than three students are accepted in one year, we adjust the acceptance goal accordingly the following year.

QERM Administrator salary and benefits make up the next largest budget allocation (typically around 40% of the budget) (Figure 9.2). These expenses are more stable than graduate student salaries, only changing to reflect changes in salary and UW benefits rates.

An administrative supplement for the Director (8%) and operating costs make up the remainder of the budget (7%). These are relatively unchanged across biennia.

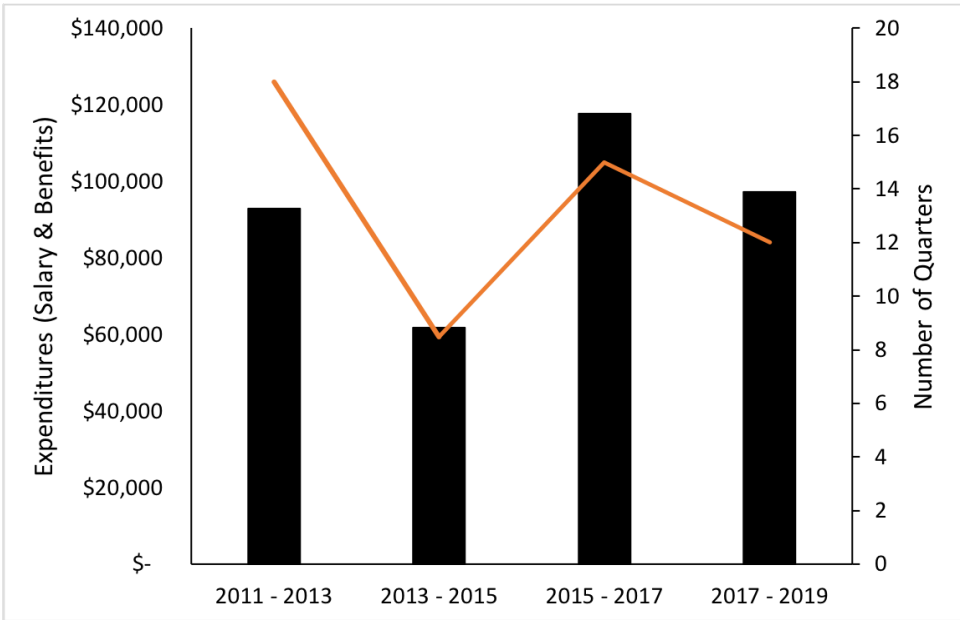

Figure 9.1: Expenditures on graduate student salary support, 2011 biennium to present (bars) and number of quarters supported (orange line). 2017 - 2019 expenditures are estimates

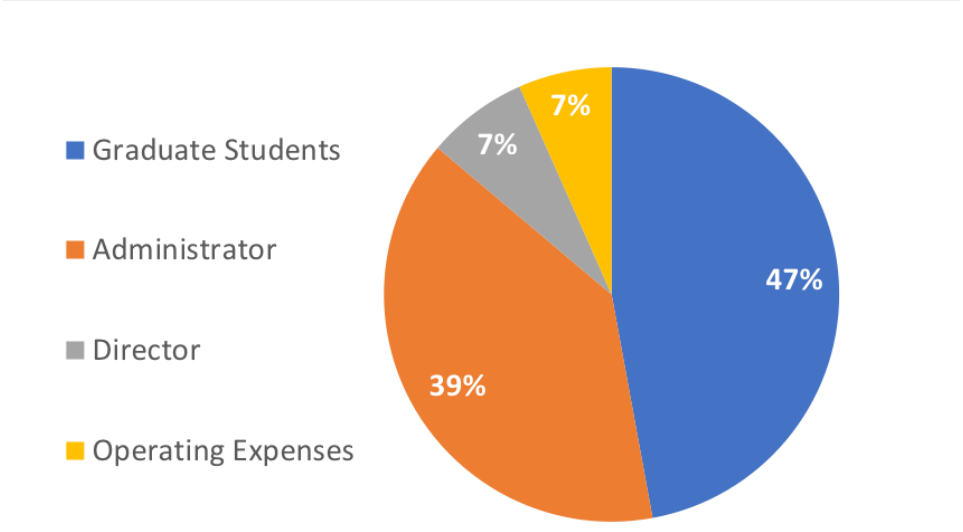

Figure 9.2: Breakdown of expenditures 2011 - 2019. Total expenditures equaled $784,132

QERM is fortunate to have the J.W. Conquest Endowment Fund established though generous donations by the Conquest family and 17 other donors (section 9.1). In the past ten years, this fund has been used to support student travel to conferences. With recent changes to the J.W. Conquest Endowed Fund, the fund will now also be used to support student fellowships.

A smaller fund, the Quantitative Ecology and Resource Management (QERM) Modelers' Endowment provides support to QERM students in developing mechanistic models of biological and ecological systems. Another small general fund, the QERM Fund for Excellence and Innovation, has been used over the past several years to support first-year student travel to conferences without a requirement that they present. This fund was expended in 2017.

9.1 Budget Lists and Descriptions

Budget 74 - 1680. Indirect Cost Supported Budget. Covers basic operating expenses, Director's administrative stipend and associated retirement and benefits

Budget 06–1689. State Budget. Covers funding for graduate research assistantships (12 quarters of funding per biennium) and supports an 0.5 FTE administrative position (Graduate Program Advisor), and retirement and benefits associated with these positions.

Budget 65–4320 /80–1453. J.W. Conquest Endowment Fund. Used to provide financial assistance to graduate students affiliated with QERM

Budget 80–1453. Quantitative Ecology and Resource Management (QERM) Modelers' Endowment. Supports QERM students in developing mechanistic models of biological and ecological systems.

Budget 65–9568. Fund for Excellence and Innovation. Supports first-year student travel to conferences without requiring they present (expended in 2017).

9.2 How does the unit evaluate whether it is making best use of its current funding?

Over the past three biennia, 91.2% to 94.5% of the budget has been allocated to cover the salaries of the administrative staff position, director's stipend, first-year student research assistant positions, and benefits (Figure 9.2). The remaining 5.5% to 8.8% has been allocated to operating costs and a discretionary fund (discontinued in 2015) to cover expenses such as office supplies, prospective student travel, food, telecommunication expenses, etc. The Director approves expenditures on the operating expenses budget.

Endowments are used solely to support students, as established by the donors.

9.3 Describe Fund-raising/Development Plan, or Grant/Contract-getting Strategies

QERM does not have a formal development plan, but now that the program is part of the College of the Environment, we intend to work with College advancement staff to create one. We do occasionally receive donations from alumni and faculty to the J.W. Conquest Endowment Fund.

10

Appendix C. Information about Faculty

We have compiled faculty CVs and placed them on a privately accessible google site: http://sites.google.com/a/uw.edu/2018–2019-quantitative-ecology-and-resource-management-review/self-study-site-visit/facultycvs

10.1 List of Faculty and Research Areas

1. Ernesto Alvarado, Research Associate Professor. Environmental and Forest Sciences. Wildland fire
2. Chris Anderson, Associate Professor. Aquatic and Fishery Sciences. Policy and management, fishery economics
3. James Anderson, Research Professor. Aquatic and Fishery Sciences. Fish passage, cognitive science, biodemography, mathematical ecology. H = 10
4. Andrew Berdahl, Assistant Professor. Aquatic and Fishery Sciences. Movement ecology, theoretical ecology, collective movement, ecological modeling, computer vision. H = 9
5. Trevor Branch, Associate Professor, Aquatic and Fishery Sciences. Marine mammals, population dynamics, marine fisheries, policy and management. H = 38
6. Lauren Buckley, Associate Professor, Biology. Functional ecology, evolution, and biogeography in changing environments. H = 31
7. David Butman, Assistant Professor. Environmental and Forest Sciences; Civil & Environmental Engineering Influence of humans and climate on carbon cycling at the intersection of terrestrial and aquatic systems. H = 17
8. Sarah J. Converse, Associate Professor. Environmental and Forest Sciences & Aquatic and Fishery Sciences. Quantitative population ecology and deci-

sion science. H = 21

9. Timothy Essington, Professor, Aquatic and Fishery Sciences. Marine fish ecology and biology, food web interactions, marine fisheries, Estuarine/coastal ecosystems. H = 43
10. Beth Gardner, Assistant Professor. Environmental and Forest Sciences. Statistical modeling to assess populations and distributions for fish, wildlife, and other organisms. H = 28
11. Ray Hilborn, Professor. Aquatic and Fishery Sciences. Ecosystem modeling, salmon ecology, policy and management, stock assessment, Bayesian analysis. H = 90.
12. Gordon Holtgrieve, Assistant Professor. Aquatic and Fishery Sciences. Ecosystem ecology: animals control of ecosystem functioning, terrestrial-aquatic linkages, global biogeochemical cycles, and fisheries conservation. H = 18
13. John Horne, Professor. Aquatic and Fishery Sciences. Aquatic ecology, fisheries acoustics, scale-dependent spatial variance. H= 30
14. Mark Kot, Associate Professor. Applied Mathematics. Mathematical biology. H = 28
15. Joshua Lawler, Professor. Environmental and Forest Sciences.Landscape ecology, conservation biology. H = 44
16. Tim Leung, Associate Professor. Applied Mathematics. Commodity markets, stochastic modeling for infrastructure investment, pricing and risk management. H = 15
17. Julian D. Olden, Professor. Aquatic and Fishery Sciences. Invasive species, conservation biogeography, freshwater fish ecology, quantitative ecology. H = 72.
18. Andre Punt, Professor. Aquatic and Fishery Sciences. Biomathematics, multispecies modeling, population dynamics, stock assessment. H= 62
19. Sergey Rabotyagov, Associate Professor, Environmental and Forest Sciences. Environmental economics and applied econometrics. H = 13
20. Jennifer Ruesink, Professor. Biology. Ecosystem engineering, biological invasions, and disturbance-recovery trajectories in estuaries.
21. Daniel Schindler, Professor. Aquatic and Fishery Sciences. Ecosystem ecology of aquatic systems; Climate impacts on ecosystems. H= 65
22. John Skalski, Professor. Aquatic and Fishery Sciences. Population estimation, environmental sampling, effects assessment. H = 24
23. David Smith, Professor. Global Health. Spatial dynamics of infectious diseases, the evolution of resistance, and disease eradication. H = 71.

24. E. Ashley Steel, Affiliate Associate Professor. Statistics & Aquatic and Fishery Sciences. Aquatic ecology and statistics. H= 27

25. Patrick Tobin, Associate Professor. Environmental and Forest Sciences. Population dynamics and spatiotemporal ecology of insects. H = 28

26. Sandor Toth, Associate Professor. Environmental and Forest Sciences. Natural resource informatics. H = 8

27. Aaron J. Wirsing, Associate Professor. Environmental and Forest Sciences. Dynamics of interacting wildlife populations, both terrestrial and marine. H= 34

11

Appendix D. Student Publications

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1. Gallucci VF, Taylor IG, Erzini K. 2006. Conservation and management of exploited shark populations based on reproductive value. Canadian Journal of Fisheries and Aquatic Sciences 63:931–42.

2. Danielsdottir MG, Brett MT, Arhonditsis GB. 2007. Phytoplankton food quality control of planktonic food web processes. Hydrobiologia 589: 29–41.

3. Hyun SY, Sharma R. 2007. Bayesian decision analysis for status of Snake River spring-summer Chinook salmon *Oncorhynchus tshawytscha* populations at extinction risk. Fisheries Science 73: 808–816.

4. Ishii HT, Ford ED, Kennedy MC. 2007. Physiological and ecological implications of adaptive reiteration as a mechanism for crown maintenance and longevity. Tree Physiology 27: 455–462.

5. Kennedy MC, Ford ED, Singleton P, Finney M, Agee JK. 2008. Informed multi-objective decision-making in environmental management using Pareto optimality. Journal of Applied Ecology 45: 181–192.

6. Lubetkin SC, Zeh JE, Rosa C, George JC. 2008. Age estimation for young bowhead whales (*Balaena mysticetus*) using annual baleen growth increments. Canadian Journal of Zoology 86: 525–538.

7. A'Mar ZT, Punt AE, Dorn MW. 2009. The impact of regime shifts on the performance of management strategies for the Gulf of Alaska walleye pollock (*Theragra chalcogramma*) fishery. Canadian Journal of Fisheries and Aquatic Sciences 66: 2222–2242.

8. A'Mar ZT, Punt AE, Dorn MW. 2009. The evaluation of two management strategies for the Gulf of Alaska walleye pollock fishery under climate change. ICES Journal of Marine Science 66: 1614–1632.

9. Cunningham KM, Canino MF, Spies IB, Hauser L. 2009. Genetic isolation by distance and localized fjord population structure in Pacific cod (*Gadus macrocephalus*): limited effective dispersal in the northeastern Pacific Ocean. Canadian Journal of Fisheries and Aquatic Sciences 66: 153–166.

10. Gurarie E, Anderson JJ, Zabel RW. 2009. Continuous models of population-level heterogeneity inform analysis of animal dispersal and migration. Ecology 90: 2233–2242.

11. Gurarie E, Andrews RD, Laidre KL. 2009. A novel method for identifying behavioural changes in animal movement data. Ecology Letters 12: 395–408.

12. Kennedy MC, Ford ED. 2009. Two-criteria model assessment shows that foliage maintenance in old-growth *Pseudotsuga menziesii* requires both delayed and sequential reiteration. Trees-Structure and Function 23: 1173–1187.

13. Li T, Anderson JJ. 2009. The vitality model: A way to understand population survival and demographic heterogeneity. Theoretical Population Biology 76: 118–131.

14. Taylor IG, Gallucci VF. 2009. Unconfounding the effects of climate and density dependence using 60 years of data on spiny dogfish (*Squalus acanthias*). Canadian Journal of Fisheries and Aquatic Sciences 66: 351–366.

15. Wang SZ, Morishima G, Sharma R, Gilbertson L. 2009. The Use of Generalized Additive Models for Forecasting the Abundance of Queets River Coho Salmon. North American Journal of Fisheries Management 29: 423–433.

16. Rollins MF, Vu NV, Spies IB, Kalinowski ST. 2009. Twelve microsatellite loci for lake trout (*Salvelinus namaycush*). Molecular Ecology Resources 9: 871–873.

17. A'Mar ZT, Punt AE, Dorn MW. 2010. Incorporating ecosystem forcing through predation into a management strategy evaluation for the Gulf of Alaska walleye pollock (*Theragra chalcogramma*) fishery. Fisheries Research 102: 98–114.

18. Canino MF, Spies IB, Cunningham KM, Hauser L, Grant WS. 2010. Multiple ice-age refugia in Pacific cod, *Gadus macrocephalus*. Molecular Ecology 19: 4339–4351.

19. Kennedy MC. 2010. Functional-structural models optimize the placement of foliage units for multiple whole-canopy functions. Ecological Research 25: 723–732.

20. Parsons AL, Skalski JR. 2010. Quantitative Assessment of Salmonid Escapement Techniques. Reviews in Fisheries Science 18: 301–314.

21. See KE, Feist BE. 2010. Reconstructing the range expansion and subsequent invasion of introduced European green crab along the west coast of the United States. Biological Invasions 12: 1305–1318.

22. Broms K, Skalski JR, Millspaugh JJ, Hagen CA, Schulz JH. 2010. Using Statistical Population Reconstruction to Estimate Demographic Trends in Small Game Populations. Journal of Wildlife Management 74:310–7.

23. Atwood, E,Duffy-Anderson JT, Horne JK, Ladd C. 2010. Influence of mesoscale eddies on ichthyoplankton assemblages in the Gulf of Alaska. Fisheries Oceanography 19(6): 493–507.

24. Garrison TM, Hamel OS, Punt AE. 2011. Can data collected from marine protected areas improve estimates of life-history parameters? Canadian Journal of Fisheries and Aquatic Sciences 68: 1761–1777.

25. Gurarie E, Suutarinen J, Kojola I, Ovaskainen O. 2011. Summer movements, predation and habitat use of wolves in human modified boreal forests. Oecologia 165: 891–903.

26. Matarese AC, Spies IB, Busby MS, Orr JW. 2011. Early larvae of Zesticelus profundorum (family Cottidae) identified using DNA barcoding. Ichthyological Research 58: 170–174.

27. McDermott SF, Cooper DW, Guthridge JL, Spies IB, Canino MF, Woods P, Hillgruber N. 2011. Effects of Maternal Growth on Fecundity and Egg Quality of Wild and Captive Atka Mackerel. Marine and Coastal Fisheries 3: 324–335.

28. Spies IB, Stevenson DE, Orr JW, Hoff GR. 2011. Molecular systematics of the skate subgenus Arctoraja (Bathyraja: Rajidae) and support for an undescribed species, the leopard skate, with comments on the phylogenetics of Bathyraja. Ichthyological Research 58: 77–83.

29. Hinrichsen RA, Sharma R, Fisher TR. 2012. Precision and Accuracy of Estimators of the Proportion of Hatchery-Origin Spawners. Transactions of the American Fisheries Society 141: 437–454.

30. Hyun SY, Keefer ML, Fryer JK, Jepson MA, Sharma R, Caudill CC, Whiteaker JM, Naughton GP. 2012. Population-specific escapement of Columbia River fall Chinook salmon: Tradeoffs among estimation techniques. Fisheries Research 129: 82–93.

31. Hyun SY, Sharma R, Carlile JK, Norris JG, Brown G, Briscoe RJ, Dobson D. 2012. Integrated forecasts of fall Chinook salmon returns to the Pacific northwest. Fisheries Research 125: 306–317.

32. Lubetkin SC, Zeh JE, George JC. 2012. Statistical modeling of baleen and body length at age in bowhead whales (*Balaena mysticetus*). Canadian Journal of Zoology 90: 915–931.

33. Sharma R, Quinn TP. 2012. Linkages between life history type and migration pathways in freshwater and marine environments for Chinook salmon, *Oncorhynchus tshawytscha*. Acta Oecologica-International Journal of Ecology 41: 1–13.

34. Altwegg R, Broms K, Erni B, Barnard P, Midgley GF, Underhill LG. 2012. Novel methods reveal shifts in migration phenology of barn swallows in South Africa. Proc R Soc B:1485–90.

35. Rohwer S, Broms K. 2012. Use of Feather Loss Intervals to Estimate Molt Duration and to Sample Feather Vein at Equal Time Intervals Through the Primary Replacement. The Auk 129:653–9.

36. Wasser SK, Hayward LS, Hartman J, Booth RK, Broms K, Berg J, Seely E, Lewis L, Smith H. 2012. Using Detection Dogs to Conduct Simultaneous Surveys of Northern Spotted (*Strix occidentalis caurina*) and Barred Owls (*Strix varia*). PLOS ONE 7:e42892.

37. Anderson JJ, Gurarie E, Bracis C, Burke BJ, Laidre KL. 2013. Modeling climate change impacts on phenology and population dynamics of migratory marine species. Ecological Modelling 264: 83–97.

38. Burns ES, Toth SF, Haight RG. 2013. A modeling framework for life history-based conservation planning. Biological Conservation 158: 14–25.

39. Gast C, Skalski JR, Beyer DE. 2013. Evaluation of fixed- and random-effects models and multistage estimation procedures in statistical population reconstruction. The Journal of Wildlife Management 77:1258–70.

40. Courter, II, Child DB, Hobbs JA, Garrison TM, Glessner JJG, Duery S. 2013. Resident rainbow trout produce anadromous offspring in a large interior watershed. Canadian Journal of Fisheries and Aquatic Sciences 70: 701–710.

41. Dougherty DT, Hilborn R, Punt AE, Stewart IJ. 2013. Modeling co-occurring species: a simulation study on the effects of spatial scale for setting management targets. Canadian Journal of Fisheries and Aquatic Sciences 70: 49–56.

42. Gast CM, Skalski JR, Isabelle JL, Clawson MV. 2013. Random Effects Models and Multistage Estimation Procedures for Statistical Population Reconstruction of Small Game Populations. PLoS ONE 8.

43. Passolt G, Fix MJ, Toth SF. 2013. A Voronoi tessellation based approach to generate hypothetical forest landscapes. Canadian Journal of Forest Research 43: 78–89.

44. Sharma R, Velez-Espino LA, Wertheimer AC, Mantua N, Francis RC. 2013. Relating spatial and temporal scales of climate and ocean variability to survival of Pacific Northwest Chinook salmon (*Oncorhynchus tshawytscha*). Fisheries Oceanography 22: 14–31.

45. Rohwer S, Broms K. 2013. Replacement Rules for the Flight Feathers of

Yellow-Billed Cuckoos (*Coccyzus americanus*) and Common Cuckoos (*Cuculus canorus*). The Auk 130:599–608.

46. Li T, Anderson JJ. 2013. Shaping human mortality patterns through intrinsic and extrinsic vitality processes. Demographic Research 28:341–72.

47. Li T, Yang YC, Anderson JJ. 2013. Mortality Increase in Late-Middle and Early-Old Age: Heterogeneity in Death Processes as a New Explanation. Demography 50:1563–91.

48. Barbero, R, Abatzoglou, JT, Kolden, CA, Hegewisch, KC, Larken, NK, Podschwit, H. 2014. Multi-scalar influence of weather and climate on very large-fires in the Eastern United States. International Journal of Climatology. 35:2180–2186.

49. Broms KM, Johnson DS, Altwegg R, Conquest LL. 2014. Spatial occupancy models applied to atlas data show Southern Ground Hornbills strongly depend on protected areas. Ecological Applications 24: 363–374.

50. Bracis C, Gurarie E, Van Moorter B, Goodwin RA. 2015. Memory Effects on Movement Behavior in Animal Foraging. PLoS ONE 10.

51. Bolin, D, Guttorp P, Januzz A, Jones D, Novak M, Podschwit H, Richardson L, Sarkka A, Sowder C, Zimmerman A. 2015. Statistical prediction of global sea level from global temperature. Statistica Sinica 25 351–367.

52. Hurtado-Ferro F, Szuwalski CS, Valero JL, Anderson SC, Cunningham CJ, Johnson KF, Licandeo R, McGilliard CR, Monnahan CC, Muradian ML, Ono K, Vert-Pre KA, Whitten AR, Punt AE. 2015. Looking in the rear-view mirror: bias and retrospective patterns in integrated, age-structured stock assessment models. ICES Journal of Marine Science 72: 99–110.

53. Johnson KF, Monnahan CC, McGilliard CR, Vert-pre KA, Anderson SC, Cunningham CJ, Hurtado-Ferro F, Licandeo RR, Muradian ML, Ono K, Szuwalski CS, Valero JL, Whitten AR, Punt AE. 2015. Time-varying natural mortality in fisheries stock assessment models: identifying a default approach. ICES Journal of Marine Science 72: 137–150.

54. Monnahan CC, Branch TA, Punt AE. 2015. Do ship strikes threaten the recovery of endangered eastern North Pacific blue whales? Marine Mammal Science 31: 279–297.

55. Oken KL, Essington TE. 2015. How detectable is predation in stage-structured populations? Insights from a simulation-testing analysis. Journal of Animal Ecology 84: 60–70.

56. Ono K, Licandeo R, Muradian ML, Cunningham CJ, Anderson SC, Hurtado-Ferro F, Johnson KF, McGilliard CR, Monnahan CC, Szuwalski CS, Valero JL, Vert-Pre KA, Whitten AR, Punt AE. 2015. The importance of length and age composition data in statistical age-structured models for marine species.

ICES Journal of Marine Science 72: 31–43.

57. Phillips A, Kot M. 2015. Persistence in a Two-Dimensional Moving-Habitat Mode. Bulletin of Mathematical Biology 77: 2125 - 2159.

58. See KE, Holmes EE. 2015. Reducing bias and improving precision in species extinction forecasts. Ecological Applications 25: 1157–1165.

59. Stawitz CC, Essington TE, Branch TA, Haltuch MA, Hollowed AB, Spencer PD. 2015. A state-space approach for detecting growth variation and application to North Pacific groundfish. Canadian Journal of Fisheries and Aquatic Sciences 72: 1316–1328.

60. Essington TE, Moriarty PE, Froehlich HE, Hodgson EE, Koehn LE, Oken KL, Siple MC, Stawitz CC. 2015. Fishing amplifies forage fish population collapses. Proc Natl Acad Sci U S A 112:6648–52.

61. Essington TE, Siple MC, Hodgson EE, Koehn LE, Moriarty PE, Oken KL, Stawitz CC. 2015b. Reply to Szuwalski and Hilborn: Forage fish require an ecosystem approach. Proc Natl Acad Sci U S A.

62. Thorson JT, Monnahan CC, Cope JM. 2015. The potential impact of time-variation in vital rates on fisheries management targets for marine fishes. Fisheries Research 169: 8–17.

63. St John, R, Tóth SF. 2015. Spatially Explicit Forest Harvest Scheduling with Difference Equations. Annals of Operations Research 232(1): 235–57.

64. Li T, Anderson JJ. 2015. The Strehler-Mildvan correlation from the perspective of a two-process vitality model. Population Studies 69:91–104.

65. Courter LA, Garrison TM, Courter, II. 2016. Latent Toxicity of Endothall to Anadromous Salmonids During Seawater Challenge. Bulletin of Environmental Contamination and Toxicology 96: 573–579.

66. Kuriyama PT, Ono K, Hurtado-Ferro F, Hicks AC, Taylor IG, Licandeo RR, Johnson KF, Anderson SC, Monnahan CC, Rudd MB, Stawitz CC, Valero JL. 2016. An empirical weight-at-age approach reduces estimation bias compared to modeling parametric growth in integrated, statistical stock assessment models when growth is time varying. Fisheries Research 180: 119–127.

67. Monnahan CC, Ono K, Anderson SC, Rudd MB, Hicks AC, Hurtado-Ferro F, Johnson KF, Kuriyama PT, Licandeo RR, Stawitz CC, Taylor IG, Valero JL. 2016. The effect of length bin width on growth estimation in integrated age-structured stock assessments. Fisheries Research 180: 103–112.

68. Oken KL, Essington TE. 2016. Evaluating the effect of a selective piscivore fishery on rockfish recovery within marine protected areas. ICES Journal of Marine Science 73: 2267–2277.

69. Ross KL, Toth SF. 2016. A model for managing edge effects in harvest

scheduling using spatial optimization. Scandinavian Journal of Forest Research 31: 646–654.

70. Webb EE, Schuur EAG, Natali SM, Oken KL, Bracho R, Krapek JP, Risk D, Nickerson NR. 2016. Increased wintertime CO2 loss as a result of sustained tundra warming. Journal of Geophysical Research-Biogeosciences 121: 249–265.

71. St John, R, Ohman K,. Toth SF, Sandstrom, P, Korosuo A., Eriksson LO. 2016. Combining Spatiotemporal Corridor Design for Reindeer Migration with Harvest Scheduling in Northern Sweden. Scandinavian Journal of Forest Research 31: 655–63.

72. Vitense K, Wirsing AJ, Tyson RC, Anderson JJ. 2016. Theoretical Impacts of Habitat Loss and Generalist Predation on Predator–Prey Cycles. Ecological Modelling 327: 85–94.

73. Chen, W., Olden, JD. 2017. Designing flows to resolve human and environmental water needs in a dam-regulated river. Nature Communications. 8(1): 2158

74. Chen, W, Olden JD. 2017. Evaluating transferability of flow–ecology relationships across space, time and taxonomy. Freshwater Biology.

75. Giam X, Chen W, Schriever TA, Van Driesche R, Muneepeerakul R, Lytle DA, Olden JD. 2017. Hydrology drives seasonal variation in dryland stream macroinvertebrate communities. Aquatic Sciences 79: 705–717.

76. Harsch MA, Phillips A, Zhou Y, Leung MR, Rinnan DS, Kot M. 2017. Moving forward: insights and applications of moving-habitat models for climate change ecology. Journal of Ecology 105: 1169–1181.

77. Muradian MM, Branch TA, Moffitt SD, Hulson P-J F. 2017. Bayesian stock assessment of Pacific herring in Prince William Sound, Alaska. PLOS One. doi 0172153.

78. Monnahan CC, Thorson JT, Branch TA. 2017. Faster estimation of Bayesian models in ecology using Hamiltonian Monte Carlo. Methods in Ecology and Evolution 8: 339–348.

79. Stewart IJ, Monnahan CC. 2017. Implications of process error in selectivity for approaches to weighting compositional data in fisheries stock assessments. Fisheries Research 192: 126–134.

80. Stawitz CC, Siple MC, Munsch SH, Lee Q, Derby SR. 2017. Financial and Ecological Implications of Global Seafood Mislabeling. Conservation Letters 10:681–9.

81. Monnahan CC, Stewart IJ. 2018. The effect of hook spacing on longline catch rates: Implications for catch rate standardization. Fisheries Research 198: 150–158.

82. Oken, KL, Essington, TE, Fu, C 2018. Variability and stability in predation landscapes: A cross-ecosystem comparison on the potential for predator control in temperate marine ecosystems. Fish and Fisheries. Published on-line ahead of print

83. Moriarty, P. E., E. E. Hodgson, H. E. Froehlich, S. M. Hennessey, K. N. Marshall, K. L. Oken, M. C. Siple, et al. 2018. The Need for Validation of Ecological Indices. Ecological Indicators 84 (2018): 546–52.

84. Rinnan DS. 2018. The dispersal success and persistence of populations with asymmetric dispersal. Theoretical Ecology 11: 55–69.

85. Ross KL, Tóth SF, Jaross W. 2018. Forest Harvest Scheduling with Endogenous Road Costs. Interfaces. 48(3):260–270.

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Appendix E. Faculty Awards

— **Chris Anderson**

1. Research Scientist of the Year, University of Rhode Island College of the Environment and Life Sciences (2005)
2. Teacher of the Year, University of Rhode Island College of the Environment and Life Sciences (2005)
3. Best Paper in Marine Resource Economics 2012, Honorable Mention (2012)

— **James Anderon**

1. College of Ocean and Fishery Sciences Distinguished Research Award (1997)

— **Trevor Branch**

1. Fellow of the American Institute of Fishery Research Biologists (2014)
2. College of the Environment Outstanding Researcher award
3. Leopold Leadership Fellow (2013)
4. Carl R. Sullivan Fishery Conservation Award, American Fisheries Society (2012)

5. Ecological Society of America Sustainability Science Award (2011)
6. Young Investigator Award. Best oral presentation at the Fifth William R. and Lenore Mote Symposium (2004)

— **Lauren Buckley**

1. Future leader, Science and Technology in Society (STS) Forum (2015)
2. National Academy of Sciences Kavli Frontiers of Science Fellow (2011, 2013)

— **Sarah Converse**

1. US Fish and Wildlife Service Special Award (2016)
2. Conference Best Paper Award, Proceedings of the AAAI Conference on Artificial Intelligence (2011)
3. Department of Interior STAR Award (2011)
4. Department of Interior STAR Award (2009)

— **Tim Essington**

1. Lowell Wakefield Endowed Professorship (2008)
2. Pew Marine Conservation Fellow (2010)
3. College of the Environment Outstanding Researcher (2015)
4. American Fisheries Society Oscar Sette Award (2017)

— **Ray Hilborn**

1. International Fisheries Science Prize (2016)
2. Named University of Washington Faculty Lecturer for 2016–2017.
3. Named Fellow of American Fisheries Society (2015)
4. American Fisheries Society Carl Sullivan Conservation Award to the Alaska Salmon Research Program of the University of Washington (2012)
5. Ecological Society of America Sustainability Science Award (2011)
6. Elected Fellow of American Academy of Arts and Sciences (2010)
7. Elected Member of Washington State Academy of Sciences (2010)
8. American Institute of Fisheries Research Biologists Outstanding Achievement Award (2009)
9. Volvo Environmental Prize (shared with Carl Walters and Daniel Pauly) (2006)

10. Elected Fellow of Royal Society of Canada (2005)
11. American Fisheries Society National Award of Excellence (2005)
12. Recipient of Western Division, American Fisheries Society, Award of Excellence (2005)
13. Richard C. and Lois M. Worthington Professor of Fisheries Management (2001- 2008)
14. College of Ocean and Fisheries Sciences Distinguished Research Award (1997)
15. H. Mason Keeler Professor of Recreational Fisheries Management (1991)
16. Stevenson Memorial Lecture, Canadian Conference for Fisheries Research (1985)
17. Wildlife Society award for best paper in fisheries science. (Adaptive management of renewable resources with C. Walters)(1976)

— **Gordon Holtgrieve**

1. G.E. Likens Award for an outstanding paper by an early career scientist. Ecological Society of America Biogeosciences Section (2012)

— **Mark Kot**

1. Boeing Award for Excellence in Teaching; Department of Applied MathematicsUniversity of Washington, Seattle, WA (2017)
2. Outstanding Graduate-Level Teacher Department of Mathematics University of Tennessee, Knoxville, TN (2007)
3. Chancellor's Award for Research and Creative Achievement University of Tennessee, Knoxville, Tennessee (1989)

— **Joshua Lawler**

1. University of Washington, Leadership Excellence Project (2015–2016)
2. College of the Environment, UW, Outstanding Researcher Award (2016)
3. School of Environmental and Forest Sciences, UW, Director's Award for Service (2014)
4. Aldo Leopold Leadership Program Fellow (2013–2014)
5. Kavli Fellow, U.S. National Academy of Sciences (2013)
6. School of Environmental and Forest Sciences, UW, Exemplary Research Funding Award (2013)
7. School of Environmental and Forest Sciences, UW, Graduate Student Support Award (2012)

8. Project of the Year, Strategic Environmental Research and Development Program (2011)
9. Secretary of the Interior, Conservation Partners Award (2011)
10. School of Forest Resources, University of Washington, Exemplary Service Award (2011)
11. School of Forest Resources, University of Washington, Graduate Student Support Award (2011)
12. College of Forest Resource, University of Washington, Exemplary Research Funding Award (2009)
13. College of Forest Resource, University of Washington, Exemplary Service Award (2008)
14. College of Forest Resource, University of Washington, Exemplary Research Funding Award (2008)

— **Tim Leung**

1. Emerald Literati Network Award for Excellence (2016)
2. INFORMS Financial Services Section Best Research Paper (1st Runner up) (2008)

— **Julian Olden**

1. H.B.N. Hynes Lecturer, Canadian Rivers Institute (2015)
2. Aldo Leopold Leadership Fellow, Stanford Woods Institute for the Environment (2015)
3. Ecological Society of America – Early Career Fellow (2013)
4. Canadian Conference for Fisheries Research, Stevenson Award (2011)
5. UW College of the Environment, Outstanding Researcher Award (2010)
6. Society for Conservation Biology, Early Career Conservationist Award (2010)

— **André Punt**

1. CSIRO Gold Medal (2009)
2. College of Ocean and Fishery Sciences Distinguished Research Award (2008)
3. 2011 Best Paper Award: Fishery Bulletin (2012)
4. Oscar Elton Sette Award (2012)
5. UW Distinguished Teaching Award (2013)

6. AFS Western Division Award of Excellence (2013)
7. Elected to the Washington Academy of Sciences (2014)
8. AFS Fisheries Management Section Award of Excellence (2016)

— **John Skalski**

1. Outstanding Monograph (co-author), The Wildlife Society (2013)
2. Award of Excellence, American Fisheries Society, Western Division (2016)

— **E. Ashley Steele**

1. Fulbright Specialist Roster (2016–2020)
2. Embassy Science Fellowship, US Department of State February (2017)
3. Station Director's Award for Excellence in Science Support, PNW Research Lab (2010)

— **Sandor Tóth**

1. Fulbright Scholar to Chile (March – July 2018)
2. Donald J. & Robert G. McLachlan Endowed Professorship, School of Environmental & Forest Sciences, University of Washington, Seattle (2015 -)
3. 2013 Best Publication Award in Environment-Sustainability ", INFORMS 2013 (2013)
4. US Forest Service Chief's Honor Award for work on open space protection (2010)
5. Best Paper in Forestry-Sponsored Sessions award, INFORMS 2008 (2008)

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Appendix F. Degree Requirements

In their first year, M.S. and Ph.D. students take the required core coursework. Under the guidance of their first-year advisors and the QERM director, they identify their research advisor and second-year funding source. In their second year, students form their supervisory committees, prepare their dissertation proposals, and make

progress on their dissertations. They take electives to further their understanding in an area of emphasis (statistics, mathematical modeling, or resource management) and to gain greater insight into the environmental systems in which they expect to apply their quantitative training.

13.1 Masters of Science

Each student's progress towards the M.S. is overseen by the student's research advisor and thesis supervisory committee. A QERM thesis supervisory committee consists of two or more faculty. The chair and at least one-half of the total membership must be members of the Graduate Faculty. The chair and one other faculty member must be QERM Faculty.

In addition to coursework completion, students must also successfully complete and defend a thesis.

For students to bypass the M.S. degree, they must demonstrate achievement equivalent to M.S. Level (typically by submitting an article for publication in a peer reviewed publication), submit a bypass proposal that outlines how the scope of the M.S. Research has expanded to that equivalent of a Ph.D. They must also have a funding plan to see them through to the end of their dissertation and the approval of their committee.

13.2 Doctor of Philosophy

A doctoral degree requires a minimum of 90-quarter credits earned over a period of at least three years and completion of a dissertation. Completion of a master's degree may be applied toward one year of the doctoral program requirements. The QERM core coursework must be taken if the student obtained a master's degree from another institution. Occasionally, students initially accepted into the master's program will be allowed to proceed directly to the doctoral program as detailed in the Master's Degree By-Pass policy (section 1.1).

Ph.D. Students take the required Qualifying Exam at the end of the first academic year. The qualifying exam consists of four parts, covering optimization, mathematical ecology /biology, statistics, and applied statistics. Students are given 7 days to work on all four parts of the exam. Responses are anonymized and then given to the qualifying exam committee for grading. Typically the qualifying exam committee meets in person to review anonymous exam responses, and only learns of student identifies once a decision has been reached. Students may retake the qualifying exam one time.

Ph.D. Students must also submit a committee- approved dissertation proposal, and then take the General Exam, an oral exam involving the entire advisory committee. Students who do not pass the General Exam are permitted at most two additional re-examination attempts, at the discretion of the advisory committee. Students who fail to pass the General Exam may not continue study towards a degree.

Ph.D. students must pass the final exam, which consists of an oral presentation open to the public, followed by a question-and-answer period with the advisory committee. The reading committee approves the dissertation.

As with most Ph.D. programs, each student's progress towards the Ph.D. is overseen by the student's research advisor and doctoral supervisory committee. A QERM doctoral supervisory committee consists of four or more faculty. At least three members of a student's doctoral supervisory committee must be members of the graduate faculty and at least two members must be members of the QERM faculty.

13.3 Coursework

Degree requirements are determined by both the Graduate School and QERM. The Graduate School sets University-wide requirements for minimum scholarship, number of required credits, and continuous enrollment. A student must satisfy the Graduate School's requirements for the M.S. or Ph.D. that are in place at the time the degree is to be awarded. QERM determines the core curriculum and elective coursework. Core coursework is the same between M.S. and Ph.D. programs.

Core Coursework (30 credits):

QERM 597 - QERM Fall Seminar (2 credits)

QERM 597 - QERM Winter Seminar (2 credits)

QERM 514 - Analysis of Ecological and Environmental Data (4 credits)

STAT 516 - Stochastic Modeling of Scientific Data I (3 credits)

STAT 517 - Stochastic Modeling of Scientific Data (3 credits)

IND E 513 - Linear Optimization Models in Engineering (3 credits)

SEFS 540 - Optimization Techniques for Natural Resources (5 credits)

BIOL/FISH/CFR 567 - Topics in Advanced Ecology (3 credits)

AMATH 523 - Mathematical Analysis in Biology and Medicine (5) (even years)

--or---

AMATH 535 - Mathematical Ecology (5) (odd years)

Additional electives are selected with the guidance of the supervisory committee. These electives consist of any 400 - or 500- level course that contribute towards

student learning of quantitative methods, ecology, biology, economics, or natural resources management.

Students also take thesis credits (QERM 700 for M.S. students, QERM 800 for Ph.D. students).